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WEIGHTLESSNESS: MAN IN SPACE, A LITERATURE SURVEY

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ABSTRACT

Covered in this partially annotated bibliography is a review of literature from 1957 to August 1961 on the state of weightlessness with primary emphasis on the physiological aspect with some engineering documentation included.

The references are listed alphabetically by periodical title and corporate author in one alphabet. Both an author and subject index follows the bibliography.

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INTRODUCTION

Strictly defined, weightlessness means complete and total absence of weight or zero gravity. This word is loosely used to denote subgravity or a gravitational force of less than "one g".

In space flight a state of weightlessness exists when the gravitational pull of the earth or other celestial bodies is at zero. In such a state objects and subjects tend to float. Medical experimentation reveals that under such a condition, humans and animals, because of proprioceptive deprivation tend to become disoriented and confused but can still adapt because the tactile and visual references are operative (unless blackout occurs). The space flight of the Soviets indicates that there is little, if any, loss of locomotion and muscular control.

Since research on weightlessness goes back to 1947 (at least), this bibliography only attempts to gather the recent material from open and closed sources. Further sources are the bibliographies which are listed in the subject index and the "Index Medicus" which was not used in the compilation of this bibliography.

This bibliography presents a review of the literature on the subject. With the exception of a few samplings from earlier literature the references tend to range from 1957 to August 1961. Material prior to 1957 can be readily obtained by utilizing bibliographies cited in this report.

Items are listed alphabetically by periodical title and corporate author in one alphabet. Please request material from Technical Information Center (TIC) on the usual "Request for Data" form. Armed Services Technical Information Agency (ASTIA) AD document numbers have been given when available to facilitate ordering from TIC.

BIBLIOGRAPHY

1. ADVANCES IN THE ASTRONAUTICAL SCIENCES, PROCEEDINGS OF THE SIXTH, 18-21 JANUARY 1960.
New York, Macmillan Company, 1961.
BASIC RESEARCH IN ASTROBIOLOGY. Richard S. Young: 317-327.

This discussion pertains to one group of experiments aimed at determining the effect of zero gravity on two basic cellular phenomena - fertilization and cell division. The sea urchin eggs and sperm were used, and a device was designed by means of which sperm and eggs were mixed at the end of the acceleration phase of the flight and fertilization was accomplished during weightlessness. Some of these eggs were fixed during re-entry and some were allowed to develop for study after recovery. Cell division was studied in much the same way. The techniques and results are discussed.

2. AERONAUTICAL SYSTEMS DIVISION. TR 61-166.
WEIGHTLESSNESS AND PERFORMANCE, A REVIEW OF LITERATURE.
J. P. Loftus and L. R. Hammer. Wright-Patterson Air Force Base, Ohio: August 1961, 34 pages.

The implications of weightlessness as encountered in space flight are discussed and the known research dealing with the psychological and physiological effects of zero gravity is critically reviewed. Topics are grouped under the headings of orientation, psychomotor performance, and physiological functions, with a special section on methods of research. The major problem area indicated is the effect of weightlessness on gravity oriented sensory mechanisms, particularly the vestibular apparatus, and consequently, on both physiological functions and psychomotor performance. An extensive bibliography is included.

3. AERO/SPACE ENGINEERING. 19:36-39, May 1960.
GRAVITY PROBLEMS IN MANNED SPACE STATIONS. C. C. Clark and J. D. Hardy.

It is shown that more human experience at zero g must be available before one can conclude whether it is better while in space to stay at zero g, or, by rotation, to maintain certain centrifugal acceleration, or to have alternate periods at zero g and at higher g; table showing animal and man ascents above 100,000 feet.

4. AERO/SPACE ENGINEERING. 19:18-23, 46, September 1960.
ZERO GRAVITY MERCURY CONDENSING RESEARCH. J. G. Reitz.

5. AEROSPACE MEDICINE. 31:543-546, July 1960.
AIRBORNE GSR STUDIES A PRELIMINARY REPORT. G. J. D. Schoch.

Evidence gained from subjects which were exposed to weightlessness suggests that changes in GSR and heart rate are due primarily to emotional factors rather than physiological.

6. AEROSPACE MEDICINE. 31:661-669, August 1960.
OBSERVATIONS ON HEART RATE AND CARDIODYNAMICS DURING WEIGHTLESSNESS. G. E. Burch and S. J. Gerathewohl.

The series experiments which are described in this article indicate that the stresses which are imposed by weightlessness in aircraft and biological missile flights are well within the range of biological tolerance for human and animal organisms.

7. AEROSPACE MEDICINE. 32:137-140, February 1961.
PHYSIOLOGICAL EFFECTS OF POSTURAL DISORIENTATION BY TILTING DURING WEIGHTLESSNESS. B. G. King.

This report is concerned with observations on labyrinthine function, and specifically the function of the utricular otolith during weightlessness.

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8. AEROSPACE MEDICINE. 32:181-196, March 1961.
SYMPTOMS RESULTING FROM PROLONGED IMMERSION IN WATER: THE PROBLEM OF ZERO G ASTHENIA. A. Graybiel and B. Clark.

The principal objective of this study was to determine the effects of extended periods of weightlessness on the fitness of the human body.

9. AEROSPACE MEDICINE. 32:209-217, March 1961.
ORIENTATION TO THE VERTICAL DURING WATER IMMERSION.
J. L. Brown.

It is shown that the utricles are relatively inefficient as gravity sensors when the head is in certain positions. The simulation of zero gravity may be enhanced by utilizing these positions with water immersion.

10. AEROSPACE MEDICINE. 32:336-340, April 1961.
A STUDY OF ANIMAL REFLEXES DURING EXPOSURE TO SUBGRAVITY AND WEIGHTLESSNESS. G. J. D. Schoek.

A resume of several experiments conducted to study the role of the vestibular apparatus during states of subgravity and weightlessness is presented. The animals used were cats which were carried in an airplane. Data was collected by means of a camera recording the animals' responses.

11. AEROSPACE MEDICINE. 32:387-400, May 1961.
PSYCHOBIOLOGICAL EFFECTS OF WATER-IMMERSION-INDUCED HYPODYNAMICS. D. E. Graveline, et al.

Discussion of an experiment conducted on one subject for a seven-day period during which extensive biologic data was collected, and involving whole-body immersion in water.

12. AEROSPACE MEDICINE. 32:719-725, August 1961.
HAND-EYE COORDINATION IN WEIGHTLESSNESS. T. D. Whiteside.

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13. AEROSPACE MEDICINE. 32:726-736, August 1961.
PHYSIOLOGIC EFFECTS OF A HYPODYNAMIC ENVIRONMENT: SHORT-TERM STUDIES. D. E. Graveline and C. W. Bernard.

Experimental investigation of the effects upon human beings of 6, 12, and 24 hours of water immersion. Tilt-table and heat-chamber tests are made, and responses to headward acceleration are studied. Pertinent psychomotor tests and evaluations of muscle strength are also discussed.

14. AIRCRAFT & MISSILES. 3:52-53, July 1960.
BIOMECHANICS OF WEIGHTLESSNESS. H. T. E. Hertzberg.

15. AIRCRAFT & MISSILES. 4:26-29, June 1961.
NEW APPROACH TO ZERO GRAVITY TESTS. R. B. Levine.

Discussion of the main features of the "Null-Gravity Simulator" developed by Lockheed's Georgia Division, designed to nullify man's visual, mechanical, and inner-ear cues to gravity. The concepts of null-gravity and zero-gravity are differentiated and the principles of null-gravity simulation are studied as an introduction to the subject.

16. AIR FORCE. 42:109-110, April 1959.
THE WEIRD WORLD OF WEIGHTLESSNESS. W. Leavitt.

17. AIR FORCE. 44:112-113, April 1961.
ALL IN A WEIGHTLESS DAY'S WORK. J. S. Butz, Jr.

18. AIR FORCE. BALLISTIC MISSILE DIVISION. AIR RESEARCH AND DEVELOPMENT COMMAND. WDZPB 2.
DISCOVERER III. Inglewood, California: 1960, 50 pages.
AD-241 853

Discusses results of experiments with 4 mice sent in the two stage Discoverer.

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19. AIR FORCE. MISSILE DEVELOPMENT CENTER. TN 58-3. APPARENT MOTION OF A FIXED LUMINOUS TARGET DURING SUBGRAVITY TRAJECTORIES. G. J. D. Schoek. Holloman Air Force Base, New Mexico: February 1958. AD-135 009.

This study was to determine the effects of linear acceleration and deceleration found in flying a ballistic trajectory on the visual perception of a target in the dark. Four subjects observed a fixed luminous target while the pilot of an F-94 aircraft executed the ballistic trajectory.

20. AIR FORCE. MISSILE DEVELOPMENT CENTER. TR 58-6. SENSORY REACTIONS RELATED TO WEIGHTLESSNESS AND THEIR IMPLICATIONS TO SPACE FLIGHT. G. J. D. Schoek. Holloman Air Force Base, New Mexico: April 1958, 10 pages. AD-135 012.

Discussion of the implications of a sensory-starved environment and comparison to the conditions that will prevail in actual space flight. Recommendations for training for future space flight are presented.

21. AIR FORCE. MISSILE DEVELOPMENT CENTER. HISTORY OF RESEARCH IN SUBGRAVITY AND ZERO-G. J. S. Henrahan. Holloman Air Force Base, New Mexico: May 1958.

The subjects of subgravity and zero-gravity are studied in the form of an historical essay. Methods of studying various types of subjects (human, feline, rodent, etc.) are discussed and results of the experiments are given.

22. AIR FORCE. MISSILE DEVELOPMENT CENTER. TN 58-15. FLIGHT EXPERIMENTS ABOUT HUMAN REACTIONS TO ACCELERATIONS WHICH ARE FOLLOWED OR PRECEDED BY THE WEIGHTLESS STATE. H. J. von Beckh. Holloman Air Force Base, New Mexico: December 1958. AD-154 108

The implications for planning of manned space flight are, first, thrust values and re-entry profiles must take the lower acceleration-tolerance into consideration; and second, that adequate g-protection must be designed for high accelerations.

23. AIR FORCE. MISSILES DEVELOPMENT CENTER. TN 59-13. PERCEPTION OF THE HORIZONTAL AND VERTICAL IN SIMULATED SUBGRAVITY CONDITIONS. G. J. D. Schoek. Holloman Air Force Base, New Mexico: June 1959, 13 pages. AD-215 464

Quantitative experiments show that in simulated subgravity conditions with decreased proprioceptive input perception of the horizontal and vertical is greatly impaired. During actual space flight, artificial gravity forces may be needed to insure adequate human orientation during weightlessness.

24. AIR FORCE. OFFICE OF SCIENTIFIC RESEARCH. TN 58-208. BASIC RESEARCH IN THE FIELD OF VISION. I--ON THE ELECTRICAL RESPONSE OF THE HUMAN EYE TO RED STIMULI OF DIFFERENT SHAPE. L. R. Rositani: II--EFFECT OF PULSE SHAPE ON CRITICAL FLICKER FREQUENCY AT DIFFERENT LUMINANCE LEVELS. Marcella Bittini. AD-152 249

25. AIR FORCE. PERSONNEL TRAINING RESEARCH COMMAND. TN 57-101. THE BEHAVIOR OF EMERGENT AND DESIGNATED LEADERS IN SITUATIONAL TESTS. W. Borg: July 1957, 10 pages. AD-134 222

26. AIR RESEARCH AND DEVELOPMENT COMMAND. TR 60-7.
HUMAN FACTORS AT EXTREME ALTITUDES: SYNOPSIS AND BIBLIOGRAPHY. F. Benghart and E. Pattishall: March 1960, 111 pages.
AD-242 348

Contents: Synopsis
Ecology
Behavior and performance
Acceleration and deceleration
Weightlessness
Radiation
Instrumentation
Bibliography

27. AIR UNIVERSITY QUARTERLY REVIEW. 10:121-141, Summer 1958.
WEIGHTLESSNESS. Siegfried J. Gerathewohl.

Includes tables on responses of 47 human subjects to short periods of virtual weightlessness and discussion of psychological aspects.

28. AMERICAN SOCIETY OF MECHANICAL ENGINEERS TRANSACTIONS, SERIES E. 28:165-170, June 1961.
TRANSIENT CAPILLARY RISE IN REDUCED AND ZERO-GRAVITY FIELDS. Robert Siegel.

Experimental information given on the transient "capillary" rise of water into vertical tubes subjected to reduced and zero-gravity fields. The response in a low-gravity environment is of interest in studying the behavior of liquid systems for space vehicles.

29. ARMED FORCES MEDICAL JOURNAL. 11:786-793, July 1960.
PERCEPTION OF THE HORIZONTAL AND VERTICAL IN SIMULATED SUBGRAVITY CONDITIONS. G. J. D. Schoek.

The role of the labyrinth in sensing body position under sub gravity conditions in absence of peripheral visual cues was assessed by comparing perception of the horizontal and vertical on land and in water for several body positions. During weightlessness in actual space flight, artificial gravity forces may be needed to ensure adequate human orientation.

30. ARMED SERVICES TECHNICAL INFORMATION AGENCY.
BIO-ASTRONAUTICS. Arlington 12, Virginia: February 1959, 157 pages.
AD-211 775

A bibliography covering literature from 1952 to 1958. It comprises a list of references to reports related to the biological problems of space flight. The reports, which primarily originate from Government-sponsored research programs, may be obtained by military agencies and prime contractors of military departments.

31. ARMED SERVICES TECHNICAL INFORMATION AGENCY.
BIO-ASTRONAUTICS (SUPPLEMENT). Arlington 12, Virginia: February 1960, 43 pages.
AD-233 000

This supplement is to make available references which have been added to ASTIA since the publication of the bibliography of February 1959.

32. ARMY MEDICAL SERVICE. RESEARCH AND DEVELOPMENT COMMAND. SR-13.
SOME OBSERVATIONS ON HEART RATE AND CARDIODYNAMICS DURING WEIGHTLESSNESS. George E. Burch and Siegfried J. Gerathewohl: 13 November 1959, 14 pages.
AD-234 284

AEROSPACE MEDICINE. 31:661-669, August 1960.

Considerable efforts were made during the last decade to determine the biomedical effects of subgravity and zero-G. Animals and men were exposed to short and moderate periods of weightlessness; and their behavior, respiration, and cardiovascular functions were recorded during aircraft and rocket trajectories. The psychological factors which entered into the physiological phenomena is clearly evident through an analysis of the data obtained in zero-G experiments.

33. ARMY NAVY AIR FORCE JOURNAL. 97:21, 23 April 1960.
MAN IN SPINNING TANK OF WATER WILL TEST EFFECTS OF WEIGHTLESSNESS IN SPACE.

34. ASTRONAUTICA ACTA. 2:203, 1956.
PERSONAL EXPERIENCES DURING SHORT PERIODS OF WEIGHTLESSNESS REPORTED BY SIXTEEN SUBJECTS. S. J. Gerathewohl.

Reactions to weightlessness by passengers in a Lockheed T-33 flying a Keplerian trajectory as revealed in Air Force School of Aviation Medicine tests of 1955 and 1956.

35. ASTRONAUTICA ACTA. 1:16-24, 1958.
PRODUCING THE WEIGHTLESS STATE IN JET AIRCRAFT.
S. J. Gerathewohl, et al.

Definition of mechanical principles of gravity and acceleration for "agravic" state purposes. The relationship between the duration of the weightless state and peak altitude of the manouver are discussed.

36. ASTRONAUTICS. 2:32-34, 74-75, November 1957.
WEIGHTLESSNESS. Siegfried J. Gerathewohl.

Discussion of the physical principles of weightlessness, how it is achieved in an aircraft, and an account of human reactions to this phenomena.

37. ASTRONAUTICS. 4:26-27, 84-86, February 1959.
WEIGHTLESSNESS AND SPACE FLIGHT. H. J. von Beckh.

Deterioration of neuromuscular coordination and disorientation are considered to be originated by the weightless state per se. However, more complex problems arise during extended space flights, as well as during alternate acceleration and weightlessness, such as occurs during the ascent and re-entry of space vehicles. Results of experiments in jet aircraft are cited to show that the weightless state aggravates other physiological conditions, which, in combination, pose serious problems to man in space flight.

38. ASTRONAUTICS. 4:42-43, February 1959.
THEY FLOAT THROUGH THE AIR.

39. ASTRONAUTICS. 4:28, June 1959.
KEEPING YOUR FEET ON THE GROUND IN SPACE. J. A. Nowbauer.

A brief note given on current and projected experiments with magnetic shoes which will allow man to walk in normal fashion in spacecraft during periods of weightlessness.

40. ASTRONAUTIK (STOCKHOLM). 1(1):9-36, 1958.
SOME BIOPHYSICAL AND MEDICAL PROBLEMS INVOLVED IN MANNED SPACE FLIGHT: A REVIEW. C. J. Clemedson.
In English.

The reduced gravity or zero gravity experienced when a satellite or a space vehicle is coasting freely in space is supposed to cause no serious disturbances of the normal physiological functions of the body, but orientation and co-ordination may be difficult during the weightless state before adaptation to the new situation has taken place. In the case of long-lasting trips, the storage problems of oxygen and air-purification chemicals as well as of food and water may become critical. Photosynthetic air purification and food synthesis from algal material may be the solution in the future.

41. AVIATION AGE. 29:174-179, May 1958.
CO2 DISPOSAL, LEAKPROOFING, ZERO GRAVITY: PROBLEMS FOR SPACECRAFT AIR CONDITIONING. F. H. Green.

42. AVIATION AGE. 29:196-203, September 1958.
"APPARENT WEIGHTLESSNESS" CALLS FOR NEW DESIGN APPROACHES. Jerzy Makowski.

Discussion on the conditions of weightlessness and the design problems caused by this phenomena.

43. AVIATION MEDICAL ACCELERATION LAB. NADC-MA-5909.
ACCELERATION PROBLEMS IN SPACE FLIGHT. J. D. Hardy, et al. Johnsville, Pennsylvania: 1 October 1959, 34 pages.

The major problems associated with acceleration and the details of previous experimental work in this field using centrifuges, rocket sleds, and other simulators are described. The problem of weightlessness is discussed with special reference to Gerathewohl's investigation of human tolerance to the weightless state produced during ballistic trajectory aircraft flights. A detailed account is given of advances in high G protection, including the use of the contour couch and water immersion.

44. AVIATION WEEK. 69(25):23, 22 December 1958.
FEW PHYSIOLOGICAL CHANGES NOTED IN MONKEY'S WEIGHTLESS FLIGHT.

The longest weightless period achieved with a primate and the telemetric results are discussed.

45. AVIATION WEEK. 69(25):52-53, 55, 22 December 1958.
ZERO GRAVITY TESTS SHOW MAN CAN ADJUST TO SPACE.
Edward L. Brown.

Experiments conducted during the past six months both in the laboratory and in actual flight, in which short periods of zero gravity were achieved, reveal that there is no serious decrement in man's performance under these conditions. Without exception, the subjects were able to adjust to zero gravity conditions within seconds. It may be that longer periods of zero gravity and further tests may upset the conclusions reached to date, but, as of now, weightlessness does not appear to create as serious a problem for crews as biomedical scientists had predicted.

46. AVIATION WEEK. 72(21):54-59, 23 May 1960.
NEW METHODS PROBE SPACE FLIGHT HAZARDS. Evart Clark.

Current and projected investigations on the effects of radiation and of weightlessness on humans in space are discussed.

47. CAMBRIDGE RESEARCH CENTER. TN 61-7.
TEMPORARY THRESHOLD ELEVATION PRODUCED BY CONTINUOUS AND "IMPULSIVE" NOISES. Walter Spieth and W. J. Trittipoe: 1961.

48. CANADIAN AVIATION (TORONTO). 33:8-11, March 1960.
DEFENCE RESEARCH MEDICAL LABORATORIES SCIENTISTS PROBE MAN'S SPACE LIMITATIONS. P. Brannan.

The work of the Defence Research Medical Laboratories at Downsview, Ontario, Canada, towards the solution of the problems of weightlessness and motion sickness in space travel is discussed. Muscular deterioration, circulatory changes, and problems of movement, as results of the weightless condition, are briefly considered. Experiments on motion sickness resulting from the utilization of angular acceleration to counteract weightlessness is also described.

49. FLIGHT (LONDON). 61:298-300, 14 March 1952.
MAN WITHOUT GRAVITY: THE PHYSIOLOGICAL AND PSYCHOLOGICAL PROBLEMS OF SPACE FLIGHT. L. N. Thompson.

The principal physiological functions of the human body such as respiration, circulation, and digestion, are primarily muscular in action and, therefore, independent of gravitational pull. The author summarizes other problems that will arise in actual space flight, such as the need for atmospheric circulation because of lack of convection currents, prevention of blackouts during high take-off accelerations, protection from radiation, the possibility of infection by alien viruses and germs encountered on other planets, and the need of proper preparation against psychological crises on extended flights.

50. FLUG-REVUE (STUTTGART). 2:22-25, February 1959.
THE DANGEROUS G. M. Jager.
In German.

The physiologic effects of G forces and human G-tolerance limits are reviewed, and protective measures and current experiments, such as tests in water immersion chambers, are discussed.

51. FORCES AERIENNES FRANCAISES (PARIS). 14(159):789-823, May 1960 and 14(160):969-986, June 1960.
PHYSIOLOGY OF SPACE FLIGHT. R. Grandpierre, et al.

Small abstract in AEROSPACE MEDICINE. 31:873, October 1960.

The following subjects are reviewed - acceleration and deceleration tolerances, weightlessness, radiation, prolonged life in a space cabin, oxygen regeneration, utilization of urine and collection of water vapor, and the nutritional requirements of astronauts.

52. FUSEES (PARIS). 161-165, May 1957.
QUELQUES ASPECTS PHYSIOLOGIQUES DU VOL "SANS PESANTEUR".
P. Biget and H. Boiteau.
In French.

Review of the physiological aspects of interplanetary flight emphasizing problems of the gravity-free state.

53. GROUND SUPPORT EQUIPMENT. 2(4):83-85, August-September 1960.
ASTRONAUT SUPPORT PROBLEM. C. Adams.

A study of man's water requirements in space and an analysis of eating and drinking experiments conducted under zero-gravity conditions are presented.

54. HUMAN FACTORS. 2(2):62-69, May 1960.
INTERNATIONAL LIST OF HUMAN FACTORS FILMS. C. W. Carter.

This annotated bibliography presents 54 references to films dealing with human factors problems in man-machine design. The subjects covered include emergency escape and survival systems, zero gravity studies, medical aspects of high intensity noise, illumination and dark adaptation, anthropometrical techniques, simulated decompression studies, aircrew fatigue problems, and the effects of whole body vibration on human performance. The references are categorized by source in order to facilitate procurement of certain films desired by the reader.

55. INSTITUTE OF RADIO ENGINEERS TRANSACTIONS ON MILITARY ELECTRONICS. MIL-4(2-3):284-287, April-July 1960.
BASIC RESEARCH EFFORTS IN ASTROBIOLOGY. R. S. Young and J. L. Johnson.

The need is cited for the development of instrumentation capable of accurately measuring and telemetering various physiologic responses of a wide variety of cellular systems subjected to accelerative forces, to conditions of vacuum, and to zero-gravity.

56. INTERAVIA. 14:390-392, April 1959.
PILOTS BEYOND THE STRATOSPHERE.

57. INTERNATIONAL ASTRONAUTICAL CONGRESS, PROCEEDINGS OF THE VIIIth, 1957.
Wien: Springer-Verlag, 1958.
PRODUCING THE WEIGHTLESS STATE IN JET AIRCRAFT.
S. J. Gerathewohl, et al: 533-542.

In the conclusion it is stated that the pilot had flown all zero-gravity research flights at the School of Aviation Medicine and had experienced weightlessness 3 minutes each flight or a total of 11 hours with no apparent physiological effects.

58. INTERNATIONAL ASTRONAUTICAL CONGRESS, PROCEEDINGS OF THE IXth, 1958.
Wien: Springer-Verlag, 1959.
FLIGHT EXPERIMENTS ABOUT HUMAN REACTIONS TO ACCELERATIONS WHICH ARE FOLLOWED OR PRECEDED BY WEIGHTLESSNESS.
H. J. von Beckh: 507-525.

Alteration of weightlessness and accelerations results in a decrease of acceleration tolerance and of the efficiency of physiologic recovery mechanisms. The implications for planning manned space flight are, first, that thrust values and re-entry profiles must take the lower acceleration tolerance into consideration, and second, that adequate G protection must be designed for the pilot, to prevent dangerous effects of unavoidable high accelerations.

59. INTERNATIONAL ASTRONAUTICAL CONGRESS PROCEEDINGS OF THE Xth, 1959.
Wien: Springer-Verlag, 1960.
ON THE TECHNICAL REALIZATION OF SUBGRAVITY AND WEIGHTLESSNESS. O. Wolasek: 202-210.

Considers the problem of a technical realization of subgravity and weightlessness on earth and under the full effects of the force of gravity. Practical methods are presented with the aim of conducting research work in space technics and medicine.

60. IOWA ENGINEER. 60(4):26-28, January 1960.
SPACE MEDICINE. R. Dostal and T. Kersey.

This is the first of a series of two articles explaining the problems men will encounter when they venture into space. The effects of weightlessness and cosmic radiation are discussed in this issue.

61. JOURNAL OF AMERICAN MEDICAL ASSOCIATION. 172(7):665-668, 13 February 1960.
PHYSIOLOGICAL ASPECTS OF HYPERGRAVIC AND HYPOGRAVIC STATES: APPLICATION TO SPACE FLIGHT. J. E. Ward.

The extremes in gravitational forces which will confront men in space flight are described. Also discussed are the functional problems of the human body when subjected to periods of zero gravity.

62. JOURNAL OF AVIATION MEDICINE. 21:395, 1950.
POSSIBLE METHODS OF PRODUCING THE GRAVITY-FREE STATE FOR MEDICAL RESEARCH. H. Haber and F. Haber.

63. JOURNAL OF AVIATION MEDICINE. 23:373, 1952.
PHYSICS AND PSYCHOPHYSICS OF WEIGHTLESSNESS, VISUAL PERCEPTION. S. J. Gerathewohl.

64. JOURNAL OF AVIATION MEDICINE. 23(6):594-596, 1952.
THE CONCEPT OF WEIGHT IN AVIATION. H. Haber.

For purposes of aviation engineering and medicine, the concept of weight is redefined. Six dynamic situations are illustrated, in which the three forces are represented as vectors.

65. JOURNAL OF AVIATION MEDICINE. 25:235, 1954.
EXPERIMENTS WITH ANIMALS AND HUMAN SUBJECTS UNDER SUB AND ZERO GRAVITY CONDITIONS DURING THE DIVE AND PARABOLIC FLIGHT. H. J. von Beckh.

66. JOURNAL OF AVIATION MEDICINE. 25(4):412-419, 1954.
COMPARATIVE STUDIES ON ANIMALS AND HUMAN SUBJECTS IN THE GRAVITY-FREE STATE. S. J. Gerathewohl.

A review is presented of the existing knowledge on the psycho-physiological aspects of sub- and zero-gravity conditions during dives and in parabolic flight; special emphasis is placed on the investigations of H. J. von Beckh (1954).

67. JOURNAL OF AVIATION MEDICINE. 28:7, 1957.
SENSOMOTOR PERFORMANCE DURING WEIGHTLESSNESS--EYE-HAND CO-ORDINATION. S. J. Gerathewohl and H. D. Stallings.

68. JOURNAL OF AVIATION MEDICINE. 28:345-355, August 1957.
THE LABYRINTHINE POSTURE REFLEX (RIGHTING REFLEX) IN THE CAT DURING WEIGHTLESSNESS. S. J. Gerathewohl and H. D. Stallings.

Experiments dealing with the otolith functions of the cat in order to shed light on the vestibular processes during sub- and zero-gravity.

69. JOURNAL OF AVIATION MEDICINE. 28:447-460, October 1957.
THE BIOLOGIC RESPONSE TO OVERPRESSURE. I--EFFECTS ON DOGS OF FIVE TO TEN-SECOND DURATION OVERPRESSURES HAVING VARIOUS TIMES OF PRESSURE RISE. D. Richmond, et al.

70. JOURNAL OF AVIATION MEDICINE. 28:531-534, December 1957. A NEW LOOK AT AVIATION PHYSIOLOGY. Harvey E. Savely and James P. Henry.

Discussion emphasizing the need for more study of the nervous system in aviation physiology and for a closer alignment with psychology.

71. JOURNAL OF AVIATION MEDICINE. 28:553-558, December 1957. PHYSIOLOGIC FACTORS IN AIRCRAFT ACCIDENTS IN THE UNITED STATES AIR FORCE. Eugene B. Kemeeei.

Study concluding that the factors affecting the normal physiologic state of the pilot are contributing rather than primary cause of major aircraft accidents.

72. JOURNAL OF AVIATION MEDICINE. 29:283-286, April 1958. AN APPROACH TO THE PHYSIOLOGIC SIMULATION OF THE NULL-GRAVITY STATE. L. A. Knight.

73. JOURNAL OF AVIATION MEDICINE. 29:371-374, May 1958. UNUSUAL PULMONARY LESIONS IN FLYING PERSONNEL. R. J. Solomon, et al.

Description of pulmonary investigations performed to determine unusual lesions and presentation of 10 case studies.

74. JOURNAL OF AVIATION MEDICINE. 29:386-391, May 1958. EFFECT OF ALTITUDE AND OXYGEN UPON PRIMARY TASTE PERCEPTION. B. Finkelstein and R. Pippitt.

Results indicating that no effects of either altitude or breathing pure oxygen on primary taste sensations were found.

75. JOURNAL OF AVIATION MEDICINE. 29:428-432, June 1958. REQUIREMENTS FOR EXPERIMENTAL ZERO GRAVITY PARABOLAS. Julian E. Ward.

76. JOURNAL OF AVIATION MEDICINE. 29:504-516, July 1958.
EXPERIMENTS DURING WEIGHTLESSNESS: A STUDY OF THE OCULO-AGRAVIC ILLUSION. S. Gerathewohl and H. Stallings.

77. JOURNAL OF HEAT TRANSFER TRANSACTIONS ASME, SERIES C. 81: 230-236, 1959.
A PHOTOGRAPHIC STUDY OF BOILING IN THE ABSENCE OF GRAVITY. R. Siegel and C. M. Usiskin.

78. JOURNAL OF SOUTH AFRICAN INTERPLANETARY SOCIETY. 24-29, April-September 1954.
SPACE MEDICINE. Herbert Segal.

Medical problems under weightless conditions outside the earth's gravitational field in terms of selection of the crew, take off, flight, landing, and life on the objective.

79. JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY. 73-81, March-April 1956.
GRAVITY CHANGES IN AIRCRAFT AND SHIPS. H. J. von Beckh.

80. JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY. 17(9): 285-288, May-June 1960.
SOME CONSEQUENCES OF WEIGHTLESSNESS AND ARTIFICIAL WEIGHT. M. P. Lansberg.

Physiological consequences of weightlessness are discussed. Artificial ventilation will be necessary, because of the absence of convection. In the absence of gravitational clues to position, some disorientation may occur and motor activities may have to be relearned, but muscular atrophy is not likely to be a real hazard. It would be unwise to extrapolate from what is experienced during parabolic flights to what can be expected during semipermanent weightlessness.

81. JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA. 54: 211-215, October 1960.
BIOSCIENCES RESEARCH AND SPACE PROBLEMS. M. G. Whillans.

82. LIBRARY OF CONGRESS. SCIENCE OF TECHNOLOGICAL SECTION. 60-61. SOVIET RESEARCH ON GRAVITATION, AN ANALYSIS OF PUBLISHED LITERATURE. Washington, D. C.: October 1960, 352 pages. AD-246 700

Contents: Correlation of Stanyukovich's public statements on weightlessness with views expressed by other Soviet-area scientists; the problem of gravitation; status of Soviet research on gravitation; correlation of Soviet and Western research; general references; bibliography - Soviet area; bibliography - Western world; annual total of publications on gravitation in USSR and other Soviet-area countries; biographies; map showing geographic locations of outstanding specialists on gravitation in the Soviet area; English translations of articles in the Russian language.

83. MACHINE DESIGN. 32:30, 9 June 1960.
ZERO GRAVITY TROUBLES: AIR FORCE FINDS BUBBLES MISBEHAVE, TUBES WON'T FEED IN WEIGHTLESS STATE.

84. MAN IN SPACE: THE UNITED STATES AIR FORCE PROGRAM FOR DEVELOPING THE SPACECRAFT CREW. Kenneth F. Gantz, Duell, Sloan, and Pearce, New York, 1959.

WEIGHTLESSNESS. Siegfried J. Gerathewohl: 108-132.

Discusses physical concepts, operational aspects, and psychological aspects of weightlessness. Reviews experiments with humans.

85. MECHANICAL ENGINEERING. 79:1029-1036, November 1957.
MAN AND HIS THERMAL ENVIRONMENT.

Discussion in terms of factors in heat stress, the body as a heat exchanger, reaction to extreme heat and cold, exposure to infrared radiation, and histolic studies of burns.

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86. MEDICINE AERONAUTIQUE (PARIS). 13(2):177-188, 1958.
THE PRESENT STATE OF ANIMAL AND HUMAN EXPERIMENTATION IN WEIGHTLESS FLIGHT. A. P. Gilbert, et al.
In French with English summary.

A discussion is presented of current animal and human experiments on weightless flight.

87. MISSILES AND ROCKETS. 6:33-34, 29 February 1960.
ASTRONAUTS WILL REQUIRE LESS SLEEP. D. Zyletro.

88. MISSILES AND ROCKETS. 6:32, 2 May 1960.
LOCKHEED WEIGHTLESSNESS SIMULATOR BEING BUILT.

89. MISSILES AND ROCKETS. 8:36, 22 May 1961.
WEIGHTLESSNESS LOWERS PERFORMANCE. H. M. David.

90. MISSILI (ROMA). 2(1):5-20, February 1960.
PROBLEMS OF SPACE MEDICINE. T. Lomonaco.
In Italian with English summary.

The main psycho-physiologic problems which concern man traveling in space are considered and discussed on the basis of recent research and discoveries. Included are the effects of acceleration on the body. Particular reference is made to a series of experiments on weightlessness performed in the "Central di Studi e Ricerche di Medicina Aeronautica", Rome, by means of a specially constructed device, the so-called "subgravity tower."

91. MUNCHENER MEDIZINISCHE WOCHENSCHRIFT. 101(32):1345-1349, 1959.
AEROMEDICAL PROBLEMS OF WEIGHTLESSNESS. H. von Diringshofen.
In German.

The transition from airflight to spaceflight makes weightlessness one of the most important problems of aerospace medicine.

FORM A1153-5-6 AMA REV. 2-61

92. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. TN D-761. FIRST PLANNING CONFERENCE ON BIOMEDICAL EXPERIMENTS IN EXTRATERRESTRIAL ENVIRONMENTS, HELD UNDER THE AUSPICES OF NASA, WASHINGTON, D. C., 20 JUNE 1960. 85 pages. AD-250 068

Thirty of the nations leading experimental biologists conferred with the staff of the NASA Office of Life Science Programs. The group recommended emphasis on the following: extraterrestrial life, effects of simulated extreme environments, cellular and biological systems in space conditions, decontamination of space probes and vehicles, effects of space on biological rhythms and animal orientation, and photosynthesis in ecosystems.

93. NAVAL AIR DEVELOPMENT CENTER. AVIATION MEDICAL ACCELERATION LAB. MA-6033.
GRAVITY PROBLEMS IN MANNED SPACE STATIONS, REPORT NO. 8. C. Clark and J. Hardy. Johnsville, Pennsylvania: 29 March 1961, 30 pages. AD-255 592

Unpowered flight above an atmosphere will produce weightlessness throughout a non-rotating space vehicle or along the axis of rotation of a rotating vehicle and if man is to live in space stations the relative merits and problems of living in a gravitational or in a weightless environment must be resolved.

94. NAVAL AIR DEVELOPMENT CENTER. AVIATION MEDICAL ACCELERATION LAB. MA-6107.
SOME PHYSIOLOGICAL CHANGES OBSERVED IN HUMAN SUBJECTS DURING ZERO G STIMULATION BY IMMERSION IN WATER UP TO NECK LEVEL. E. L. Beckman, et al. Johnsville, Pennsylvania: 10 April 1961, 25 pages. AD-256 727

It was found that water immersion up to neck level produces an unnatural physiological situation in that, during respiration, the inspired air inflates the lungs to atmospheric pressure while the external pressure against the chest, abdomen, and legs, due to the water, is greater than atmospheric. This situation is equivalent to "negative pressure breathing".

95. NORTH AMERICAN AVIATION, INC., MISSILE DIVISION. 59-437.
ANNOTATED BIBLIOGRAPHY AND LITERATURE SURVEY OF BEHAVIOR OF LIQUIDS AND VAPORS UNDER ZERO-GRAVITY CONDITIONS.
Engineering Library: 1 December 1959, 6 pages, 7 citations.

96. OPERATIONS RESEARCH, INC. NAVTRADEVCEN 560-1.
WEIGHTLESSNESS, TRAINING REQUIREMENTS AND SOLUTIONS.
Barry G. King, et al. Silver Spring, Maryland:
3 March 1961, 102 pages.
AD-259 512

Physical principles and biological mechanisms relevant to human performance under conditions of weightlessness have been explained that the trainee can develop an appreciation of how the unaccustomed environment will affect his behavior. Special emphasis has been given to changes of man's center of mass, the mechanisms of postural reflexes, and anticipated changes in the sensory input spectrum and implications of such changes.

97. PHYSICAL THERAPY REVIEW. 40:584-587, August 1960.
EXERCISE IN A WEIGHTLESS ENVIRONMENT. P. Potts and J. I. Bowring.

98. PHYSICS AND MEDICINE OF THE ATMOSPHERE AND SPACE.
Edited by Otis O. Benson, Jr. and Hubertus Strughold.
New York, John Wiley and Sons: 1960.
PHYCHOPHYSIOLOGIC AND MEDICAL STUDIES OF WEIGHTLESSNESS.
Siegfried J. Gerathewohl and Julian E. Ward: 422-424.

Reports study of group for weight-tolerance at the USAF School of Aviation Medicine. Tabulator account of results with psychological reactions.

99. REVISTA DE LA REAL ACADEMIA DE CIENCIAS DE MEDRIS.
52(2):141-145, 1958.
ARTIFICIAL SATELLITES AND INTERPLANETARY TRAVEL: PHYSIOLOGICAL EFFECTS OF CHANGE IN GRAVITY. M. Velasco de Pando.
In Spanish.

A corrected and extended version of an analytical study on the launching of space rockets. Attempts to correlate a mathematically basic physiological and physical parameter.

100. RIVISTA DI MEDICINA AERONAUTICA (ROME). 21(4):655-690, October-December 1958.
WIDE RANGE ACCELERATION INVESTIGATIONS IN MAN AND ANIMALS.
R. Margaria.
In English.

On the basis of elementary laws of physics describing the behavior of bodies floating in a fluid and subjected to acceleration, the possibility of protecting the body against accelerative forces is investigated. Attention is given to the prone as opposed to the upright position, and to immersion of the body in a fluid of the same density.

101. RIVISTA DI MEDICINA AERONAUTICA (ROME). 21(4):691-704, October-December 1958.
VARIATIONS OF PSYCHOPHYSIOLOGICAL DATA IN MAN SUBJECTED TO CHANGES IN ACCELERATIONS BETWEEN THREE AND ZERO G.
T. LoMonaco, et al.
In Italian with English summary.

Studies were carried out concerning psychophysiologic effects of weightlessness on human subjects. States of subgravity were achieved by drops from a tower 14-m. high, which is described in detail.

102. RIVISTA DI MEDICINA AERONAUTICA E SPAZIALE (ROME). 23(4): 439-456, October-December 1960.
BEHAVIOR OF SOME PERCEPTUAL-MOTOR FUNCTIONS DURING THE TRANSITION FROM ABOUT TWO TO ZERO G AND THE EFFECT OF TRAINING: EXPERIMENTS EXECUTED WITH THE SUBGRAVITY TOWER.
T. LoMonaco, et al.
In Italian with English summary (p. 506).

Six subjects executed a repetitive task with electrical switches following a pre-established pattern while at rest and when launched on a subgravity tower to alternate states of hyper- and zero gravity.

103. SCHOOL OF AVIATION MEDICINE. 59-35.
PHYSIOLOGIC RESPONSE TO WEIGHTLESSNESS. INITIATION OF MICTURATION. J. Ward, et al. Brooks Air Force Base, Texas: August 1959.
AD-229 813

Twenty-six subjects were exposed to a total of 37 separate jet aircraft flights during which zero-gravity parabolic flight maneuvers were performed. Scheduling of body waste elimination should be incorporated into the crewman's standard operating procedures and check list. Special consideration must be given to the design and development of a satisfactory urine receptacle.

104. SCHOOL OF AVIATION MEDICINE. 60-68.
AN EXPLORATORY STUDY OF SLEEP CHARACTERISTICS IN HYPODYNAMIC ENVIRONMENT. R. McKenzie, et al. Brooks Air Force Base, Texas: October 1960, 8 pages.

Sleep characteristics were monitored and evaluated by EEG technics during an exploratory study of biologic hypodynamics produced by body immersion. The hypothesis is advanced that the biologic function of sleep may be to provide a recovery period from the neuromuscular debt acquired from the effects of counteracting the forces of gravity. This has several implications for space travel in the weightless state.

105. SCHOOL OF AVIATION MEDICINE. 60-72.
AN EXPLORATORY STUDY OF CHANGES IN PROFICIENCY IN A HYPODYNAMIC ENVIRONMENT. Bryce Hartman, et al. Brooks Air Force Base, Texas: July 1960, 13 pages.
AD-244 121

Simulated weightlessness for a prolonged period produced by the body immersion technic. Changes in psychomotor efficiency was assessed during immersion and after return to the normal environment of one G.

106. SOCIETY OF AUTOMOTIVE ENGINEERS JOURNAL. 68:56-57, September 1960.
ZERO G SPACE BOILERS. R. A. Trusela and R. C. Clodfelter.

Visual observations during zero-g flight tests show that bubbles do not combine. Film boiling will probably predominate in zero-g environments.

107. SOCIETY OF AUTOMOTIVE ENGINEERS JOURNAL. 69:52-54, February 1961.
MAN'S ANTICS DURING ZERO GRAVITY. F. L. Brown.

Description of sensations experienced during brief periods of zero g produced in a C-131B transport aircraft. The necessity of magnetic shoes, and of experiences with their use, are mentioned.

108. SPACE. 25-27, January-March 1959.
COCKPIT OF FIRST SPACESHIP MAY BE LIKE A PADDED CELL.
M. P. Lansberg.

Reprint of paper presented at British Interplanetary Society Symposium, London, 1958. Discusses problems arising from continual weightlessness including air circulation, body perception, and muscular activity.

109. SPACEFLIGHT. 1:109, 1957.
THE PROBLEM OF WEIGHTLESSNESS. A. E. Slater.

110. SPACE JOURNAL. 2(2):13-14, 41-45, December 1959.
THE WEIGHTLESS MAN. H. D. Stallings and S. J. Gerathewohl.

The condition of zero gravity is discussed and its effects on man are described.

111. SPACE TECHNOLOGY. 1:8-10, April 1958.
WEIGHTLESSNESS CRUCIAL SPACEMAN FACTOR. R. Hawkes.

112. SPACE WORLD. 1:14-15, July 1960.
MAN IN A TUB. John Rublowsky.

Captain Graveline's seven days in 400 gallons of water.

113. SPACE WORLD. 1:44-45, August 1961.
G FORCES. Willy Ley.

114. TEXAS STATE JOURNAL OF MEDICINE. 55:267-274, April 1959.
THE PRESENT STATUS OF THE PROBLEM OF WEIGHTLESSNESS.
P. A. Campbell and S. J. Gerathewohl.

Weightlessness is discussed from the point of orientation, control, space sickness, cardiodynamics, and nutrition and elimination.

115. UNITED STATES AIR FORCE. SCHOOL OF AVIATION MEDICINE. 60-88.
THE PHYSIOLOGIC EFFECTS OF HYPODYNAMICS INDUCED BY WATER IMMERSION. D. E. Graveline and Bruno Balke: September 1960, 12 pages.

Investigation of the hypodynamic effects of body immersion in water on orthostatic tolerance, on cardio-respiratory adaptability to physical stress, and on other biologic and psychophysiologic parameters.

116. UNITED STATES ARMED FORCES MEDICAL JOURNAL. 10:172-177, February 1959.
BIBLIOGRAPHY OF SPACE MEDICINE. C. A. Roos.

This compilation of 446 references covers aspects of space medicine such as sealed cabin problems, acceleration and deceleration, fractional and zero gravity, cosmic radiation, nutrition in space flight, survival problems, psychological and social problems, ground crew problems, and extraterrestrial aspects. Entries are arranged chronologically starting with 1958 and going back as far as 1928.

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117. UNITED STATES ARMED FORCES MEDICAL JOURNAL. 11:1162-1168, October 1960.
EFFECTS OF ZERO GRAVITY UPON THE CARDIOVASCULAR SYSTEM.
L. J. Stutman and R. Olsen.

Some preliminary investigations of the effects of zero gravity upon the cardiovascular system. Position in zero gravity field does not seem to affect the cardiovascular system. Hypotheses are proposed for the potential circulatory difficulties that will hamper a person's return to earth.

118. UNITED STATES DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. 617.
BIBLIOGRAPHY OF SPACE MEDICINE. Washington, D. C.: 1958, 49 pages.

119. WELTRAUMFAHRT (GERMANY): 10(1):21-28, March 1959.
INVESTIGATIONS ON THE EFFECT OF WEIGHTLESSNESS ON THE HUMAN BODY. H. J. von Beckh.

Abstracted in INDEX AERONAUTICUS, LONDON. 15:56, July 1959.

120. WELTRAUMFAHRT (GERMANY). 10(3):62, September 1959.
NINE MINUTES OF WEIGHTLESSNESS IN SPACE.

121. WRIGHT AIR DEVELOPMENT CENTER. TN 59-149.
THE EFFECT OF ZERO GRAVITY ON FLUID BEHAVIOR AND SYSTEM DESIGN. J. J. Neiner. Wright-Patterson Air Force Base, Ohio: April 1959.
AD-228 810

The results are given of a test program which shows the behavior of fluids under the method of obtaining this environment is described. The effect of this environment on fluids of different densities and viscosities is presented as well as a discussion of the behavior of air bubbles released in the fluid and methods of fluid transfer under this condition.

122. WRIGHT AIR DEVELOPMENT CENTER. TN 59-327.
WALKING UNDER ZERO-GRAVITY CONDITIONS. J. C. Simons. Wright-Patterson Air Force Base, Ohio: October 1959. AD-232 469

Experiments were conducted with permanent magnetic sandals which enable a man to walk with an approximately normal gait under weightless conditions. A basic index was formulated to define magnetic requirements in terms of the inductive forces required to hold a subject stationary. A vector analysis of the one-g walking gait is made and elements of a zero-gait for further study using variable power electromagnetic shoes are proposed.

123. WRIGHT AIR DEVELOPMENT CENTER. TR 53-484, Part III, Vol. II. THE PHYSIOLOGICAL BASIS FOR VARIOUS CONSTITUENTS IN SURVIVAL RATIONS. III--THE EFFICIENCY OF YOUNG MEN UNDER CONDITIONS OF MOIST HEAT: APPENDICES OF METHODS AND ORIGINAL DATA. Frederick Sargent, II, et al. Wright-Patterson Air Force Base, Ohio: April 1958, 921 pages.

124. WRIGHT AIR DEVELOPMENT CENTER. TR 56-364.
LINEAR DISTANCE CHANGES OVER BODY JOINTS. I. Emanuel and J. Barter: February 1957, 38 pages.
AD-118 003

Measurements of joints and joint complexes on 30 men. Summary statistics and design values are presented for 48 linear distant changes.

125. WRIGHT AIR DEVELOPMENT CENTER. TR 57-114.
AN ANALYSIS OF THE ACTIONS OF ADRENAL CORTICAL STEROIDS AND OTHER AGENTS ON THE CEREBRAL CORTEX OF THE RABBIT.
G. A. Misrahy: March 1958, 91 pages.
AD-118 077

126. WRIGHT AIR DEVELOPMENT CENTER. TR 59-94.
MAN'S ABILITY TO APPLY TORQUES WHILE WEIGHTLESS.
E. Dzendolet and J. Rievley. Wright-Patterson Air Force Base, Ohio: April 1959, 29 pages.
AD-220 363

The torque that a maintenance man can exert within a space vehicle while weightless, and hence tractionless, is analyzed; and the consequences of applying these torques while tractionless are calculated. It is tentatively concluded that standard anthropometric data can legitimately be extrapolated to the weightless condition.

127. WRIGHT AIR DEVELOPMENT DIVISION. TR 60-129.
MANUAL APPLICATION OF IMPULSES WHILE TRACTIONLESS.
Ernest Dzendolet. Wright-Patterson Air Force Base, Ohio: February 1960, 12 pages.
AD-238 021

The percentage of naive subjects who, while tractionless in a horizontal plane and anchored by one handhold, push in or pull out a plunger in one motion against various frictional forces and travel distances, decreases directly as the force and distance required. The impulse-momentum theorem is discussed.

128. WRIGHT AIR DEVELOPMENT DIVISION. TR 60-601.
DISCRIMINATION OF DIFFERENCES IN MASS OF WEIGHTLESS OBJECTS.
D. Rees and N. Copeland. Wright-Patterson Air Force Base, Ohio: December 1960, 20 pages.
AD-252 161

Absence of gravity results in the loss of many familiar kinesthetic cues of weight and friction necessary to man for object discrimination and manipulation. Man's ability to discriminate small differences in weight was studied.

129. WRIGHT AIR DEVELOPMENT DIVISION. TR 61-184.
THE EFFECT OF TRANSIENT WEIGHTLESSNESS ON VISUAL ACUITY. L. D. Pigg and W. N. Kama. Wright-Patterson Air Force Base, Ohio: March 1961, 22 pages.

Studies of visual acuity in subjects exposed to short periods of weightlessness on aircraft flown through "zero G" trajectories involving transitions from one g through two and one-half g.

130. WRIGHT AIR DEVELOPMENT DIVISION. TR 61-257.
PHYSIOLOGIC EFFECTS OF A HYPODYNAMIC ENVIRONMENT SHORT TERM STUDIES. D. Graveline and G. Barnard. Wright-Patterson Air Force Base, Ohio: March 1961, 14 pages.

Study of the effects of a hypodynamic situation (complete immersion in water) upon four subjects of differing build and athletic prowess. Tilt table, centrifuge, and heat chamber evaluations were conducted in conjunction with pertinent psychomotor, anthropometric, urine and blood tests.

131. ZAPISNIK (PRAGUE). 3(14):16-17, July 1959.
FIVE SECONDS IN A WEIGHTLESS STATE. D. Minkewitzova.. In Czechoslovakian.

In a zero-gravity experiment conducted by the Czechoslovak Institute of Aviation Medicine, two physicians of the institute were used as subjects. Electrocardiograms were taken on one of the subjects. Several consecutive zero-gravity experiments, each lasting five seconds, were performed from 2000-meter altitude, using IL-14 aircraft of Czechoslovak make. After approximately 30 minutes the aircraft landed and the experiment was complete. Almost all of the members of the test crew were ill and nauseated.

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